UNITED STATES DISTRICT COURT
DISTRICT OF MASSACHUSETTS
WESTERN DIVISION

Springfield, Massachusetts

CIVIL ACTION No. 05-30016-MAP

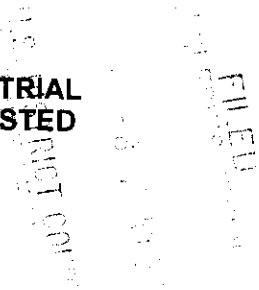
Marcos Y. Kleinerman, Pro Se
215 Sunset Avenue, Amherst, MA 01002
PLAINTIFF

vs.

Michael M. Salour, James H. Bechtel and IPITEK
(also known as IPICOM, Inc.)
DEFENDANTS

AMENDED COMPLAINT

JURY TRIAL REQUESTED



PARTIES

1. The plaintiff, Marcos Y. Kleinerman ("the plaintiff"), is a resident of Amherst, Hampshire County, Massachusetts. He is a physicist, a chemist and an inventor, and his main means of livelihood derives from the licensing of some of his U.S. patents.

2. Defendant IPITEK ("IPITEK"), also known as IPICOM, Inc. ("IPICOM"), is a business company which made and sold throughout the United States and a plurality of foreign countries, optical temperature sensors which the plaintiff alleges have infringed at least three of his US patents. IPITEK has its main place of business in Carlsbad, California.

3. Defendant Michael M. Salour ("Salour") was at all times related to the matter of this civil action, and is believed to be presently, IPITEK's CEO.

4. Defendant James H. Bechtel ("Bechtel") was, at all times related to the matter of this civil action, IPITEK's Senior Vice President.

JURISDICTION AND VENUE

5. This is an action for declaratory and monetary relief. Jurisdiction over the defendants for the wrongful acts alleged in this Complaint is established by **35 U.S.C. §§ 271**, **284** and **286**, the Massachusetts General Laws ("**MGL**"), chapter **223A**, other applicable federal and state statutes and the common law of the Commonwealth of Massachusetts. Venue is established by virtue of the plaintiff's residence in the Commonwealth and by the defendants' engaging in acts herein complained of in the Commonwealth; and further, by defendant IPITEK engaging in business including sales in

Massachusetts.

FACTS

6. On or about August of 2002 defendant IPITEK published an article in the trade magazine "SENSORS" describing its fiber optic temperature sensor model "LumiTherm 500", which operates with a photo-luminescent probe including a chromium-doped crystalline garnet material known as Cr:YAG, and a method and device, both patented by the plaintiff under US patents **4,708,494**, **5,090,818** and **5,332,316**, for measuring temperature from the luminescence decay time of said crystalline material. A true copy of said article is attached hereto as **EXHIBIT A**.

7. IPITEK had never informed the plaintiff that it was using his patented technology.

9. On or about September 26, 2002 the plaintiff mailed a Notice of Patent Infringement (the "Notice") to IPITEK's CEO, defendant Salour. A copy of the Notice is attached hereto as **EXHIBIT B**.

9. IPITEK responded to plaintiff's Notice with a letter dated October 10, 2002 from defendant Bechtel asking the plaintiff to "provide an analysis of the claims of [plaintiff's] patents as compared to the structure of [IPITEK's] products". A copy of Bechtel's letter is attached hereto as **EXHIBIT C**.

10. On October 31, 2002, at Bechtel's request, the plaintiff mailed to him a letter containing detailed information showing that IPITEK's LumiTherm 500 sensor infringed claims **12**, **13** and **19** of the plaintiff's US patent **4,708,494**, claims **1**, **2**, **7** and **8** of the plaintiff's US patent **5,090,818** and claims **1**, **2**, **3 4**, **8**, **9**, **10**, **11**, **12**, **13** and **14** of the plaintiff's US patent **5,332,316**. Copies of plaintiff's 10/31/02 letter to defendant Bechtel and the text of said patent claims are attached hereto as **EXHIBIT D**.

11. By letter dated 26 November 2002 defendant Bechtel responded to the plaintiff's 10/31/02 communication denying that IPITEK had any product operated as described in IPITEK's own published article in SENSORS magazine (paragraph **6**, *supra)* or which infringed any claims of any said patents **4,708,494**, **5,090,818** or **5,332,316**. Upon information and belief, Bechtel's denial was untrue and he knew it was untrue when he made it. A copy of Bechtel's letter is attached hereto as **EXHIBIT E**.

12. In order to determine whether the probe of IPITEK's LumiTherm 500 sensor included the Cr:YAG probe material as stated by defendant IPITEK itself in said published article (paragraph **6**,

supra), the plaintiff ordered on January 2 2003 said probe from IPITEK's distributor Davis Inotek ("Inotek"). The order was confirmed by Inotek as order No. W253314. A copy of Inotek's confirmation is attached hereto as **EXHIBIT F**.

13. The ordered probe (paragraph **12**, *supra)* was ***not*** shipped to the plaintiff. On or about January 14, 2003 Inotek informed the plaintiff by telephone that the sales manager of IPITEK (called IPICOM by Inotek) had directed INOTEK to cancel the plaintiff's order.

14. On January 15, 2003 the plaintiff faxed a letter to IPITEK's sales manager asking why IPITEK refused to sell said probe to the plaintiff. A true copy of the faxed letter is attached hereto as **EXHIBIT G.** The plaintiff has received no reply as of the date of filing of this Complaint.

COUNT I against IPITEK for patent infringement

15. The plaintiff incorporates by reference herein paragraphs **6** through **14**, inclusive.

16. IPITEK's manufacture and marketing of its LumiTherm 500 instrument and any other fiber optic temperature sensing device based on the temperature-dependent decay time of the luminescence of a material as recited in any of the claims **12**, **13** or **19** of the plaintiff's US patent **4,708,494**, claims **1**, **2**, **7** or **8** of the plaintiff's US patent **5,090,818** and/or claims **1**, **2**, **3 4**, **8**, **9**, **10**, **11**, **12**, **13** or **14** of the plaintiff's US patent **5,332,316** constitute infringement of said patents and a violation of **35 U.S.C. § 271**.

WHEREFORE the plaintiff prays

a) that the court find that defendant IPITEK has infringed said claims of said US patents **4,708,494**, **5,090,818** and **5,332,316**;

b) that the plaintiff's damages for all infringement committed during the time beginning six years prior to the date of filing of the original Complaint up to the dates of expiration of said US patents **4,708,494**, **5,090,818** and **5,332,316** be assessed upon defendant IPITEK, including royalties at the rate of 8.00 percent of gross sales of IPITEK products that infringed plaintiff's patents, interest and costs pursuant to **35 U.S.C. §§ 284** and **286,** except for products which IPITEK can show were sold for applications explicitly subject of an exclusive license granted by the plaintiff to any third party; and

c) that said damages be doubled or trebled if the court finds, as alleged herein, that said

conduct on the part of defendant IPITEK was willful and knowing.

COUNT II for malicious interference against all defendants

17. Plaintiff incorporates by reference herein paragraphs **6** through **14,** inclusive..

18. The aforesaid conduct of the defendants, making willful false denials (paragraph **11**, *supra*) of having products that infringed plaintiff's patents and prohibiting its distributor Inotek to sell to plaintiff its advertised probe of IPITEK's LumiTherm 500 sensor was intended to

(i) deceive the plaintiff regarding the facts relating to IPITEK's infringement of plaintiff's patents;

(ii) wrongly preventing plaintiff from verifying, from an examination of the probe of LumiTherm 500 sensor, that IPITEK was knowingly infringing plaintiff's patents; and

(iii) maliciously interfering with plaintiff's exercise of his rights granted him under the US patent laws.

WHEREFORE the plaintiff prays

a) that the plaintiff's damages be assessed upon all the defendants; and

b) that judgment enter in his favor against the defendants jointly and severally in the amount of plaintiff's damages and costs.

DEMAND FOR JURY TRIAL

Plaintiff hereby demands a jury trial as to all issues in this action so triable.

Dated: June 7, 2005

Marcos Y. Kleinerman, Pro Se
Plaintiff
215 Sunset Avenue
Amherst, MA 01002

Certificate of Service

I hereby certify that a true copy of this Amended Complaint was served today by First Class mail to the cousel for the defendants, James A.G. Hamilton, at Perkins, Smith & Cohen LLP, One Beacon Street, 30th Floor, Boston, MA 02108-3106.

June 7, 2005

Marcos Y. Kleinerman, Pro Se
Plaintiff

A

EXHIBIT A

EXHIBIT A

Sensors Magazine, August 2002

A Fiber-Optic
Temperature Sensor

This fluorescence-decay temperature probe combines the advantages of optical fiber with a unique r measurement system that minimizes inaccuracies due to signal loss from the fiber and connector.

Jeff Stokes and Gail Palmer, IPITEK

In the LumiTherm 500 temperature sensor, a fiber probe communicates optically with a temperature sensitive phosphor at the probe tip (see Figure 1).

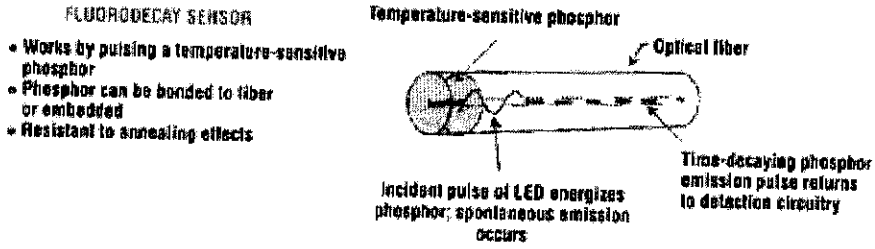


Figure 1. The fluorodecay sensor works by pulsing a temperature-sensitive phosphor that can be embedded or bonded to the fiber. The probe require a single-mode fiber, and it is resistant to annealing effects.

The phosphor is excited via the optical fiber by a low power source inside the instrument, and the resulting luminescence travels back to a detector. The source and detector, along with signal-proces electronics and control functions, are combined into a single compact module, to which the near end the probe attaches by a standard, SMA fiber-optic connector. Excitation and emission light are separ in the module to enhance sensitivity.

The phosphor tip, at the far end, is either embedded in the medium to be measured or placed in cont with its surface. The probe is composed of silica fiber and various jacketing layers, all of which are st over the full temperature measurement range of the instrument. The phosphor, which is typically stal much higher temperatures than the glass itself, can respond to temperature in various ways: change quantum efficiency, spectral shift of emission and/or excitation bands, and alteration of the fluoresce lifetime (decay time).

Of these temperature-dependent mechanisms, change in decay time provides the most robust apprc to measuring temperature. The reason is that lifetime changes can be quantified in a manner indepe of instrumental and environmental variables. To monitor lifetime, the excitation source is pulsed. Historically, this type of measurement has been made by sampling the decaying fluorescence intens two accurately separated times, t_1 and t_2. This yields signals:

$$I(t_1) = I_0 e^{-\frac{t_1}{\tau(T)}} + C$$

$$I(t_2) = I_0 e^{-\frac{t_2}{\tau(T)}} + C$$

where:

(T) = temperature-dependent fluorescence lifetime
C = offset due to background crosstalk, ambient light, etc.

To extract the temperature, the conventional approach takes the ratio:

$$R \ldots \frac{I(t_1)}{I(t_2)}$$

which for ***C*** = 0 can be solved for ***(T)*** to yield the simple relationship:

$$\tau(T) = \frac{\Delta t}{\ln R}$$

where:

$t = t_2 - t_1$ = time interval from first to second reading of emission intensity

It is also possible to perform linear fits to the logarithm of the intensity in order to determine the deca constant from the slope of the trendline, but this approach requires a great deal of computation and h sampling rates to achieve acceptable accuracy. Sampling a decay signal with a timing uncertainty, quantization error, δt, means that the resulting lifetime will be determined with uncertainty given by:

$$\tau + \delta\tau = \frac{(t_2 - t_1 + \delta t)}{\ln(R + \delta I)}$$

IPITEK's patented approach resolves all the issues of offsets (background, ambient, etc.) and stringe sampling requirements in a computationally efficient manner. Using phase-sensitive rectification of th signal, offsets can be eliminated and sampling errors reduced dramatically.

Fluorescent lifetime is an intrinsic property of the phosphor material, dependent exclusively on phosp temperature, except for quite negligible pressure dependence. Knowing ***(T)***, then, the temperature is found from a look-up table established by prior calibration of the probe. Thus, the measurement proc entails only the ratio of correlated readings combined with the accurate determination of a time interv while all other instrumental and environmental variables automatically cancel out. Also, the simple fo the decay law permits accurate interpolation of data between calibration points. This leads to a temperature sensor requiring only one initial calibration but applicable to a variety of tasks in widely different environments.

The patented phosphor used in the standard LumiTherm 500, $Y_3Al_5O_{12}:Cr^{3+}$ (Cr:YAG), is highly suit measurements in the –50°C to 500°C range. The crystalline nature of the host, combined with its hig melting point (1950°C), make it extremely stable over the measurement range, with properties that a reversible as temperature is cycled. The fluorescence decay measurement uses the well-known pair narrow lines, or R lines, emitting red light near 694 nm, which can be pumped (excited) with reasona efficiency by narrow or broadband green and yellow light. The fluorescence is detected high with qua efficiency and speed by a standard Si photodiode, and the pulsed excitation light is provided by an o shelf LED. The R lines obey a single exponential decay law over the range of interest, leading to pre of measurement and stability of calibration as explained above.

Accuracy and Reliability

The small thermal mass of the phosphor element at the fiber tip of the LumiTherm 500 means rapid accurate temperature measurement of the material of interest, whether the tip is in contact with the surface or embedded in the medium. Mounting the active phosphor at the end of a small optical fiber allows placement of the sensor in difficult-to-access locations. The materials in the fiber that communicates with the phosphor exhibit low thermal conductivity as well as a narrow cross-sectiona area, minimizing heat flow to and from the active sensing element from outside the volume whose temperature is to be sampled. In contrast, standard RTDs usually have a large thermal mass and are highly conductive.

The accuracy of the fluorescent decay probe is not threatened by corrosion, as are many thermocou Probes can be manufactured with high chemical resistance. The probe requires no wires or other me parts, with the result that it is electrically nonconducting, unlike both thermocouples and RTDs. It car therefore be deployed in high-field environments or in the presence of severe EMI.

Applications

Quantitative temperature measurements are a standard scientific method for characterizing physical chemical properties. Temperature is a key indicator of the way various materials are interacting with another. QA/QC procedures quite often include processing temperatures as part of accurate documentation on how materials are handled and products are manufactured. In biomedical laboratc temperature is monitored and the data are used to optimize protocols and confirm experimental stan for sample preparation in situ—especially useful in drug uptake assays or pharmacokinetic studies. S industrial processes entailing microwave curing or drying steps are using fiber-optic probes to measu temperatures and electric field strengths during operation.

Because optical fiber can withstand harsh chemicals, chemistry labs use fiber-optic probes to monitor the temperature of electrochemical syntheses and oxidation reactions (see Photo 1). Pharmaceutical manufacturers immerse the probes in bioreactor vessels, where real-time, continuous data logging helps pinpoint changes at precise times as indicators of reaction kinetics. The information can be extremely useful in scale-up protocols and calorimetry studies.

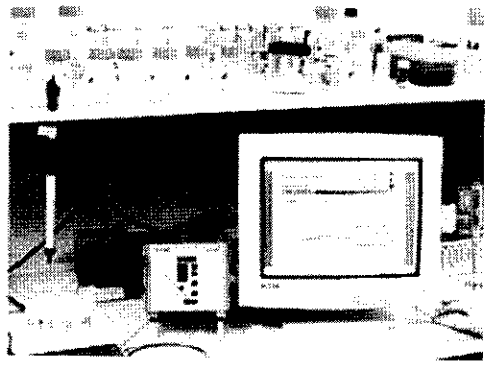


Photo 1. The LumiTherm 500's fiber-optic probe can eithe placed into surface contact with the material of interest or immersed in the sample vial. The experiment shown here monitored sample preparation over a 25 min. time course. time data were exported and charted in Lab View from Na Instruments.

Fiber-optic cable is flexible, can be produced to any length, and can be autoclaved, attributes of considerable advantage to researchers in the field of animal physiology. The cable aids in capturing temperature measurements within organs, arteries, and veins, and even intracranially. The 100–450 micron fiber diameter allows insertion of the sensors into catheters. One proposed purpose of doing so is to measure temperature gradients in arterial walls at sites of plaque inflammation. The data may be used as an indicator of potential strokes or embolisms Another promising application is brain temperature monitoring as it relates to memory and/or cognitic as an early warning of seizures or aneurysms. Because of the immunity of fiber-optic probes to RF, s optical fields, and even light sources, the technology is ideal for medical RF ablation instrumentation Here, the sensors can provide precise temperature measurement to help prevent overburn of adjacent tissue and ensure minimal tissue damage, and, in the case of tumor ablation, confirm that the temperature end point was reached.

Fiber-optic cables are also used in wind field profiling (see Photo 2), an application that requires long-distance monitoring of temperature to predict shifts in wind direction based on thermal profiling. They are also an excellent solution for utility transformer substations, where temperature plays an important diagnostic role in detecting degradation of the internal windings and thus predicting the remaining life of costly transformers. Fiber is well suited to this application since it offers no

conductive electrical path for current, whereas added wiring could cause a transformer malfunction. In addition, the oil used in transformers has a long-term destructive effect on many sensors, but fiber can resist this problem.

LumiTherm is a registered trademark of IPITEK.

Jeff Stokes was Staff Physicist at the time of this writing.

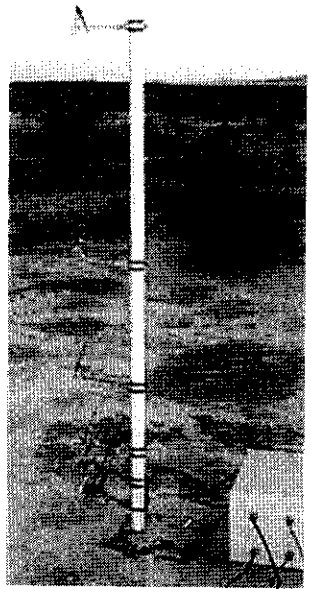


Photo 2. For wind field and tempera profiling, LumiTherm probes are sta above ground at 1, 5, 10, and 25 cm and 2 m. (Photo courtesy of Michael Brown, Los Alamos National Labora

B

EXHIBIT B

EXHIBIT B

MARCOS Y. KLEINERMAN, Ph.D.
Consultant, Fiber Optic Sensors
215 Sunset Avenue
Amherst, MA 01002
Tel: (413) 549-7124 Fax: (413) 549-7126 E-mail: marcosk@fiam.net

September 26, 2002

Michael M. Salour, CEO
Ipitek
2330 Faraday Avenue
Carlsbad, CA 92008

Subject: Notice of Patent Infringement

Dear Dr. Salour,

It has come to my attention that Ipitek is marketing a fiber optic themometer, model **LumiTherm 500**, which uses the temperature-dependent luminescence decay time of **Cr:YAG** as a temperature indicator. This luminescence decay time is determined by the thermal (Boltzmann) equilibrium between the relative occupancy numbers of the two excited emissive levels, $^{2}\mathbf{E}$ and $^{4}\mathbf{T}_{2}$, of $\mathbf{Cr}^{3+}$. Optical temperature sensors based on this phenomenon are covered by claims **12**, **13** and **19** of my US patent **4,708,494** and claims **1**, **2**, **7** and **8** of my US patent **5,090,818.** These patents are currently in force.

The first of the above-mentioned patents was issued on an application having the benefit of the filing date of August 6, 1982. The kind of sensor materials to which **Cr:YAG** belongs to, and their behavior relevant to their use as temperature sensors, were described in column **13** of US patent **4,708,494**. The class of probes based on **Cr(III)** crystalline materials, including *explicitly* the temperature-dependent equilibrium between the relative occupancy numbers of the two excited emissive levels $^{2}\mathbf{E}$ and $^{4}\mathbf{T}_{2}$ were described in column **15** of the same patent..

(You are probably aware that a fiber optic temperature sensor based on **Cr:YAG** was being sold in Europe by the German firm **Degussa** since before 1990. Both **Degussa** and the Luxtron Corporation **(Luxtron)** were communicating with me concerning my fiber optic sensor patents. Eventually my relevant technology became the subject of a (mostly) non-exclusive license to **Luxtron**, which has been marketing its 'fluoroptic' thermometers under said license since 1992. To the best of my knowledge, **Degussa** decided not to compete with **Luxtron** in the US).

Since at least one product of yours is infringing my above-mentioned patents, I respectfully request that you

a) cease as soon as possible to make, use, offer to sell or sell the **LumiTherm 500** thermometer and/or any other device or method which infringes my patents, until such time that you sign a patent licensing agreement acceptable to both myself and Ipitek, or until my relevant patents expire:

b) indicate the number of the US patent which Ipitek claims as protecting the **LumiTherm 500**;

c) provide an account of all the **LumiTherm 500** units sold since its introduction in the market, and the total income from the sales; and

d) reply as soon as possible to this message indicating what actions, if any, do you intend to take in view of this Notice, and forward a copy of your reply to my business attorney William H. Tucker, at 290 Qiuarry Street, Suite 408, Quincy, MA 02169.

In case Ipitek's infringement was inadvertent, and to avoid a similar occurrence regarding other patents of mine covering areas of common interest (I have noticed, for example, Ipitek's interest in secure fiber optic communications, one of the areas subject of one of my patents), I respectfully suggest that you download my patents (through USPTO, Delphion or another service) and check your present and/or planned products against them. I am attaching an index page to a recent patent as a guide to the contents.

C

EXHIBIT C

IPITEK
INTEGRATED PHOTONICS TECHNOLOGY
ISO 9001 Registered

EXHIBIT C

October 10, 2002

Marcos Y. Kleinerman, Ph.D.
215 Sunset Avenue
Amherst, MA 01002

Re: Your letter to IPITEK

Dear Dr. Kleinerman:

This letter responds to your letter dated September 26, 2002. Our organization has reviewed your letter. Based on the information you provided in your letter, there is no basis for a belief that any of IPITEK's products infringe the claims of your patents.

If you have information that you feel is to the contrary, please provide an analysis of the claims of your patents as compared to the structure and operation of our products. If you do so, we will respond more specifically to your claim.

Sincerely,

James H. Bechtel
Senior Vice President

Cc: William H. Tucker

2330 Faraday Avenue Carlsbad, CA 92008 Tel: (760) 438-1010 Fax: (760) 438-2412
e-mail: ipitek@ipitek.com

EXHIBIT D

D

MARCOS Y. KLEINERMAN, Ph.D.
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EXHIBIT D

FAX

To : **Dr. James H. Bechtel, Senior Vice President Ipitek**
Fax : (760) 438-2412
From : **Marcos Kleinerman**
Date : October 31, 2002
Subject: Patent Infringement
Pages : 9(including this one)

MESSAGE

Please see attached letter.

MARCOS Y. KLEINERMAN, Ph.D.
Consultant, Fiber Optic Sensors
215 Sunset Avenue
Amherst, MA 01002
Tel: (413) 549-7124 Fax: (413) 549-7126 E-mail: marcosk@fiam.net

October 31, 2002

Dr. James H. Bechtel, Senior Vice Prsident
Ipitek
2330 Faraday Avenue
Carlsbad, CA 92008

CERTIFIED, No. 7000 1530 0003 2388 2101

Subject: Your letter dated October 10, 2002, and Notice of Patent Infringement

Dear Dr. Bechtel,

I am glad that you are willing to examine my analysis of the claims of my patents as compared to the structure and operation of Ipitek's fiber optic thermometer model **LumiTherm 500**. Since you profess that you are not aware that said thermometer infringes any of the claims **12**, **13** and **19** of my US patent **4,708,494** or any of the claims **1**, **2**, **7** and **8** of my US patent **5,090,818** (I forgot to mention claims **1**, **2**, **3** **4**, **8**, **9**, **10**, **11**, **12**, **13** and **14** of my US patent **5,332,316**, which are also infringed by the **LumiTherm 500**), my explanation shall be presented at a level perhaps too elementary for a Ph.D. holder like yourself.

So let us start with Ipitek's own description off the thermometer as published in the Ipitek article "A Fiber-Optic Temperature Sensor" by your Jeff Stokes and Gail Palmer in the August 2002 issue of **"SENSORS"** Magazine. The article describes your "patented" phosphor (described as long ago as **1965** by G. Burns *et al.*, *Phys. Rev.* ***139***, A1687 (1965)) as the trivalent chromium garnet "$Y_3Al_5O_{12}$:Cr^{3+} **(Cr:YAG)**", operated in the fluorescence decay mode. As described in numerous publications since no later than 1965, the fluorescence (more properly called "photo-luminescence") of **Cr:YAG**, when excited with light of any wavelength within a spectral band characteristic for **Cr:YAG**, occurs from ***two*** excited levels of Cr^{3+}, namely the ^2E level, from which the **R** lines referred to in the article are emitted, and the higher $^4T_2$ level, which emits the "vibronic" fluorescence.

As you know, there is a temperature-dependent equilibrium between the relative occupancy numbers of the two excited emissive levels ^2E and $^4T_2$. The $^4T_2$ level has a much faster rate of fluorescence decay than the ^2E level. As temperature increases, said temperature-dependent equilibrium (you know it as a Boltzmann equilibrium) increases the occupancy number of the $^4T_2$ level relative to that of the ^2E level. As a greater proportion of the fluorescence is emitted by the faster-decaying $^4T_2$ level, the overall fluorescence decay time decreases with increasing temperature even if there is no decrease in the overall fluorescence quantum yield over a substantial portion of the useful temperature range of the thermometer.

As you also know, the fluorescence decay time is the same whether you select the fluorescence from "only" the **R** lines, only the vibronic band, or both the **R** lines and the vibronic band together. And, of course, you cannot exclude a non-negligible fraction of the vibronic fluorescence when you try to measure the fluorescence from the **R** lines only, especially at temperatures above 50°C.

The above described luminescence behavior of **Cr:YAG** has been extensively described in the literature. In addition to the Burns *et al.* reference (*supra*) you could read, *inter alia*,

- J.P. Hehir *et al.* in J. Phys. C **7**, 2241 (1974);
- G.W. Fehrenbach, *Proceedingsof the Conference of* ***Sensor '88***, *Nurenburg, Germany* (**VCH**, Wienheisn, 1988), p. 49;
- V. Fernicola and L. Crovini, *Fiber Optic and Laser Sensors XI*, SPIE Proc. Vol. **2070** (1993) p. 472;
- Z.Y. Zhang, K.T.V. Grattan, and A.W. Palmer, Phys. Rev. B **48**, 7772 (1993).
- V. Fernicola and L. Crovini, *A High Temperature Digital Fiber-Optic Thermometer,* SPIE Proc. Vol. **2360** (1994), pp. 211-214;
- Z.Y. Zhang, K.T.V. Grattan, and A.W. Palmer, Phys. Rev. B **51**, 2656 (1995).

If you examine my patent claims (attached herein), the conclusion that it covers methods and devices that use the temperature-dependent luminescence decay time of a probe belonging to a group of luminophors that includes **Cr:YAG** could not possibly escape you, without the need for me to embark on an effort to prepare a more detailed presentation. The conclusion would not escape any federal court, either, especially after testimony from experts including authorities from academia and current licensees of my patents.

I am looking forward to an amicable and prompt resolution of this issue in the form of a patent licensing agreement.

Very truly yours,

Marcos Kleinerman

cc. William H. Tucker, Esq.

Selected Claims of

US PATENT 4,708,494

sensor, said relative intensities being an indicator of the sensor temperature.

4. A method as defined by claim 1 wherein said luminescent material contains, in addition to said luminescent centers characterized by a temperature-dependent absorption of light, designated in this claim as A centers, a second kind of luminescent centers, designated in this claim as B centers, the absorption coefficient of which is approximately independent of temperature within the temperature range being measured, when illuminated as recited in subparagraph (b) of claim 1, the method of this claim additionally comprising the steps of:

(a) measuring the intensity of the luminescence emitted by the B centers, and

(b) measuring the relative intensities of the luminescence lights emitted by the A centers and the B centers, said relative intensities being an indicator of the sensor temperature.

5. A method as defined by claim 4, wherein the intensity of said excitation light varies in an oscillatory or pulsating manner with a decay time much shorter than the luminescence decay time of one, and only one of said two kinds of luminescent centers, thus generating a luminescence emission from one of said two kinds of luminescent centers the intensity of which has a time-dependence different from that of the luminescence emission from the other centers, and wherein the luminescence emissions from both said A and said B centers are directed to and detected by a single photo-detector, this method additionally comprising the steps of:

(a) separating, by means of known electrical timing techniques, the electrical signals produced at the photo-detector by the luminescence emissions from said A centers and from said B centers, and

(b) measuring the relative intensities of said separated electrical signals, said relative intensities being an indicator of the sensor temperature.

6. A method as defined by claim 2 wherein the excitation light is carried to the luminescent sensor by means of at least one optical fiber, the generated luminescence is directed to its photo-detector by means of at least one optical fiber, and the light transmitted through the luminescent material is directed to its photo-detector by means of at least one optical fiber.

7. A method as claimed in claim 1 wherein said luminescent centers are additionally characterized by emitting, when excited with light of any wavelength within a defined spectral region for said sensor, including but not limited to the spectral region recited in claim 1, luminescence lights from two excited energy levels, the relative intensities of which are a known monotonic function of temperature, the luminescence intensity from the upper of said levels increasing with an increase in temperature within the temperature range being measured, said intensity increase producing a decrease of the decay time of the luminescence emitted from said levels, and wherein the intensity of the excitation light is made to vary in an oscillatory or pulsating manner with a decay time shorter than the decay time of the sensor luminescence emitted from said two energy levels, the method additionally comprising the steps of:

(a) measuring the decay time of the sensor luminescence emitted by said two excited levels, said decay time being an additional and independent indicator of the sensor temperature, and

(b) comparing the temperature reading obtained from the intensity of the luminescence light generated by the absorption of said temperature-dependent fraction of the intensity of the illuminating light to the temperature reading obtained from said decay time of the sensor luminescence.

8. A method as defined by claim 1 wherein the excitation light is carried to the luminescent sensor by means of at least one optical fiber, and wherein the generated luminescence is directed to the photo-detector by means of at least one optical fiber.

9. A method as defined by claim 8 wherein the luminescent material is a vibronic material characterized by an optical absorption coefficient which varies as a known function of the occupancy number of at least one vibronic level.

10. A method as defined by claim 8 wherein the luminescent material is a semiconductor with a temperature-dependent absorption edge.

11. A method as defined by claim 8 wherein the luminescent material is a glass doped with a lanthanide ion having an electronic energy level which is thermally excited at the temperature being measured, the occupancy number of said electronic level increasing with an increase in temperature.

12. A method for measuring the temperature of an object or environment comprising the steps of:

(a) placing a temperature sensor in a heat flow relationship with said object or environment, said sensor consisting of a material containing luminescent centers characterized by emitting, when excited with light of any wavelength within a defined spectral region for said sensor, luminescence lights from two excited energy levels, the relative intensities of which are a known monotonic function of temperature, the luminescence intensity from the higher of said levels increasing with an increase in temperature within the temperature range being measured, said intensity increase producing a decrease of the decay time of the total luminescence from the sensor,

(b) exciting the luminescence of said sensor with light within said defined spectral region, thereby causing luminescence emissions from said two energy levels, the relative intensities of which are a know function of temperature,

(c) directing the luminescence lights emitted by said sensor to a photo-detection station, and

(d) measuring the relative intensities of said luminescence emissions from said two energy levels, said relative intensities being an indicator of the sensor temperature.

13. A method as defined by claim 12 wherein the intensity of said excitation light is made to vary in an oscillatory or pulsating manner with a decay time shorter than the decay time of the sensor luminescence emitted from said two energy levels, and wherein the measurement of the relative intensities of said luminescence emissions from said two energy levels is effected by measuring said luminescence decay time, said decay time being an indicator of the sensor temperature.

14. A temperature probe consisting of a solid luminescent material, said probe material containing therein:

(a) luminescent centers, designated herein as A centers, characterized by absorbing, when exposed to light within a defined spectral region, a fraction of the intensity of said light incident on said material, said fraction varying as a known function of the temperature of said material, and by emitting luminescence light with an intensity that varies as a

known function of the intensity of said absorbed light, and

(b) luminescent centers, designated herein as B centers characterized by an absorption coefficient and luminescence intensity which are approximately independent of temperature, within the temperature range being measured, when excited with light within said defined spectral region, the luminescence of these centers being emitted in a spectral region different from that of the luminescence of the A centers, the concentration of the B centers being such as to absorb only a fraction of said incident light within said defined spectral region.

15. A device for the optical measurement of temperature comprising:

(a) a sensor consisting of a luminescent material containing luminescent centers characterized by absorbing, when illuminated with light within a defined spectral region for said luminescent material, a fraction of the intensity of said illuminating light incident on said sensor, said fraction varying as a known function of the temperature of said sensor, said sensor emitting luminescence light with an intensity that varies as a known function of the intensity of said absorbed light,

(b) a source of luminescence excitation light within said defined spectral region,

(c) fiber optic means for directing said excitation light to said sensor, thereby generating luminescence emission,

(d) fiber optic means for directing the excitation light transmitted by said sensor and the luminescence light emitted by said sensor to a photo-detection station,

(e) a photo-detection station for measuring the intensity of said excitation light transmitted by said sensor and the intensity of said luminescence light emitted by said sensor, and

(f) means for measuring the relative values of the electrical signals generated at said photo-detection station by said excitation light transmitted by said sensor and by said luminescence light emitted by said sensor, said relative values being an indicator of the sensor temperature.

16. A device as defined by claim 15 and also comprising optical filter means for separating said excitation light transmitted by said sensor from said luminescence light emitted by said sensor.

17. A device as defined by claim 15 wherein said excitation light source is characterized by producing a recurrent light intensity which decays in a period much shorter than the decay time of the sensor luminescence, and wherein said luminescence light emitted by said sensor and said excitation light transmitted by said sensor are both directed to a single photo-detector, and also comprising electrical frequency filter means for separating said electrical signal generated by said excitation light transmitted by said sensor from said electrical signal generated by said luminescence light emitted by said sensor.

18. A device as claimed in claim 15 wherein said luminescent centers are additionally characterized by emitting, when excited with light of any wavelength within a defined spectral region for said sensor, including but not limited to the spectral region recited in claim 15, luminescence lights from two excited energy levels, the relative intensities of which are a known monotonic function of temperature, the luminescence intensity from the upper of said levels increasing with an increase in temperature within the temperature range being measured, said intensity increase producing a decrease in the decay time of the luminescence emitted from said energy levels, and wherein the intensity of the excitation light is made to vary in an oscillatory or pulsating manner with a decay time shorter than the decay time of the sensor luminescence, emitted from said two excited energy levels, the device additionally comprising:

(a) means for measuring the decay time of the sensor luminescence emitted by said two excited energy levels, said decay time being an additional and independent indicator of the sensor temperature, and

(b) electronic means for comparing the temperature reading obtained from the intensity of the luminescence light generated by the absorption of said temperature-dependent fraction of the intensity of the illuminating light to the temperature reading obtained from said decay time of the sensor luminescence.

19. A device for the optical measurement of temperature comprising:

(a) a temperature sensor consisting of a luminescent material containing luminescent centers characterized by emitting, when excited with light within a defined spectral region, luminescence light from two excited energy levels, the luminescence intensity from the higher of said levels increasing with an increase in temperature, said luminescent centers also characterized by a luminescence decay time which decreases in a known manner with an increase in temperature,

(b) a source of repetitive pulses of luminescence excitation light, the intensity of which decays in a time much shorter than the decay time of the luminescence emitted by said sensor,

(c) fiber optic means for directing said pulses of luminescence excitation light to said sensor,

(d) fiber optics means for directing said luminescence light emitted from said two excited levels emissive excited levels of said sensor to a single photo-detector, and

(e) a photo-detector and associated electronic means for measuring the decay time of said luminescence light, said decay time being an indicator of the sensor temperature.

20. A device for the optical measurement of temperature comprising:

(a) a temperature sensor consisting of a solid containing two kinds of luminescent centers designated herein as A centers and B centers, said A centers characterized by an absorption coefficient which varies as a known function of temperature when excited with light within a defined spectral region, and said B centers characterized by an absorption coefficient and a luminescence intensity which are approximately independent of temperature within the temperature range being measured, when excited with light within said defined spectral region,

(b) a source of luminescence excitation light within said defined spectral region,

(c) fiber optics means for directing said excitation light to said sensor,

(d) fiber optics means for directing the luminescence light emitted by said sensor to a photo-detection station, and

Selected claims of

US PATENT 5,090,818

In an alternate embodiment of the same invention, the luminescent screen is stationary and the distal tip of the optical fiber is attached to the object undergoing the displacement. The end result is the same: the intensity of the interrogating light spot incident on the luminescent material, and hence the intensity of the luminescence generated therein, varies as a function of the displacement of the object.

Since some changes may be made in the foregoing disclosure without departing from the invention herein disclosed, it is intended that all matter contained in the above description and depicted in the accompanying drawings be construed in an illustrative and not in a limiting sense.

I claim:

1. A temperature measuring arrangement comprising:

(a) probe means including a photoluminescent material containing luminescent centers so characterized that, when excited with transient interrogating light of a wavelength or wavelengths within a pre-determined spectral range, they emit luminescence light from two excited electronic energy levels, one of them being higher than the other and having a higher rate of luminescence decay than that of said other level, the relative intensities of the luminescence light emitted from each of said two levels varying as a function of the probe means temperature, the intensity of the luminescence light emitted from said higher level increasing with increasing temperature within a pre-determined temperature range within which the quantum efficiency of the total luminescence emitted from said two levels is approximately invariant, the combined luminescence light emitted from said two levels continuing in time beyond the termination of the transient excitation light with a decay time of its intensity which decreases in a known manner with an increase in temperature within said temperature range;

(b) a source of said interrogating light;

(c) fiber optic means for directing said interrogating light to said probe means;

(d) fiber optic means for directing a fraction of the intensity of the luminescence light emitted from said probe means to photodetector means; and

(e) photodetector means for measuring the decay time of the luminescence emitted from said probe means, said luminescence decay time being an indicator of the probe means temperature.

2. A temperature measuring arrangement as claimed in claim 1, wherein said material is chosen from the group of luminescent inorganic crystalline materials comprising beryls, magnesium oxide and garnets doped with trivalent chromium or divalent vanadium.

3. A temperature measuring arrangement as claimed in claim 1 and additionally having self-checking features, wherein the wavelengths of said interrogating light are within a spectral region within which the probe absorbs only a fraction α of the intensity of the light incident on the probe, the value of α increasing with an increase in temperature as a function of the value of the so-called Boltzmann factor $\exp(-\beta/T)$, where β is a quantity which remains substantially constant over said temperature range and T is the absolute temperature, said arrangement additionally comprising means for measuring the intensity of the luminescence light emitted by the probe and received by said photodetector means, said intensity being another indicator of the probe temperature.

4. A temperature measuring arrangement as claimed in claim 1 and additionally adapted to sense a displacement of an object, wherein said displacement varies the intensity of the interrogating light incident on said photoluminescent material at said probe means, thereby varying the intensity of said luminescence light emitted by said probe means and received by said photodetector means as a function of said displacement.

5. A temperature measuring arrangement as claimed in claim 4 and additionally adapted to measure simultaneously both temperature and a force or pressure, comprising the arrangement claimed in claim 4 wherein the position or displacement of said object is determined by the force or pressure applied on said object, and the magnitude of the force or pressure is indicated by the position or the magnitude of the displacement of said object.

6. A temperature measuring arrangement as claimed in claim 1 and additionally adapted to measure a force, wherein at least one point along said fiber optic means for directing said interrogating light to said photoluminescent probe means is under the action of the force, said force causing the attenuation of said interrogating light from an intensity P_o injected into said fiber optic means to the intensity $P_o(1-\alpha)$, where α is a fraction of unity, the magnitude of which varies as a function of the magnitude of the force being measured, thereby causing a decrease of the intensity of the luminescence light emitted by said photoluminescent probe means, the magnitude of said decrease varying with the magnitude of the force.

7. A method for measuring temperature, comprising the steps of:

(a) exposing a probe to the temperature to be measured, said probe including a photoluminescent material containing luminescent centers so characterized that, when excited with transient interrogating light of a wavelength or wavelengths within a pre-determined spectral range, they emit luminescence light from two excited electronic energy levels, one of them being higher than the other and having a higher rate of luminescence decay than that of said other level, the relative intensities of the luminescence light emitted from each of said two levels varying as a function of the probe temperature, the intensity of the luminescence light emitted from said higher level increasing with increasing temperature within a pre-determined temperature range within which the quantum efficiency of the total luminescence emitted from said two levels is approximately invariant, the combined luminescence light emitted from said two levels continuing in time beyond the termination of the transient excitation light with a decay time of its intensity which decreases in a known manner with an increase in temperature within said temperature range;

(b) illuminating said probe with said interrogating light, thereby generating luminescence light emitted by the probe;

(c) directing a fraction of the intensity of said luminescence light to photodetector means; and

(d) measuring the decay time of said luminescence light, said decay time being an indicator of the probe temperature.

8. A method for measuring temperature as claimed in claim 7, wherein said probe contains a photo-luminescent material chosen from the group of inorganic crystalline materials including beryls, magnesium oxide and garnets doped with trivalent chromium or divalent vanadium.

9. A method for measuring temperature as claimed in claim 7 wherein the wavelengths of said excitation light are within a spectral region within which said probe has a temperature-dependent optical absorption coefficient, the method additionally comprising the measurement of the time-averaged intensity of the luminescence light received by said photodetector means, said time-averaged intensity being an additional indicator of the probe temperature.

10. A method for measuring temperature as claimed in claim 7 and additionally adapted to measure the position or displacement of an object, the method comprising the additional steps of:

(a) providing an optical fiber into which the interrogating light is injected, the distal tip of which is adapted to illuminate said probe with a spot of interrogating light;

(b) providing said probe in mechanical communication with said object, and so positioned relative to the distal tip of said optical fiber that the intensity of the interrogating light spot incident on said luminescent material varies as a function of the position of the probe and, hence, of said object;

(c) thereby generating luminescence light emitted from said luminescent material, the time-averaged intensity of which is an indicator of the position of said object.

11. A method for measuring temperature as claimed in claim 7 and additionally adapted to measure the position or displacement of an object, the method comprising the additional steps of:

(a) providing an optical fiber into which the interrogating light is injected, the distal tip of which is adapted to illuminate said probe with a spot of interrogating light;

(b) providing said distal fiber tip in mechanical communication with said object, and so positioned relative to said probe that the intensity of the interrogating light spot incident on said luminescent material varies as a function of the position of said distal fiber tip and, hence, of said object;

(c) thereby generating luminescence light emitted from said luminescent material, the time-averaged intensity of which is an indicator of the position of said object.

* * * * *

Selected claims of

US PATENT 5,332,316

from the class of materials described in section 2.0 above and FIG. 3, having an absorption band including the wavelengths of the injected light, a luminescence in response to the absorption of said light, the quantum efficiency of which is substantially invariant over a temperature range of operation of the device, and a luminescence decay time τ which is a sensitive function of temperature over the same range. Under the action of the force, the microbender 92 stresses the fiber 91 and causes an attenuation of the pulsed interrogating light of an intensity P_o injected into the fiber to the attenuated intensity $P_o(1-\alpha)$, where the value of α is a function of the pressure applied to the microbender. The intensity of the light transmitted by the fiber under the microbender and incident on the luminescent tip 93 generates a luminescence therein with a time-averaged intensity I_f which is an indicator of the pressure acting on the microbender, and is independent of temperature. On the other hand, the luminescence decay time τ of the probe is a temperature indicator, independent of the force applied to the microbender. A fraction of the intensity of the luminescence emitted by the tip 93 is collected by the same fiber 91 and directed, via fiber optic coupler 94 and the fiber segment 95, to photodetector 96. The force-dependent luminescence intensity If received by the photodetector and the luminescence decay time τ processed into both temperature and force readings at the microcomputing unit 97. One can thus measure both force and temperature with a single probe, a single light source and a single photodetector.

The duration of the interrogating light pulses should be preferable much shorter than the shortest decay time of the probe luminescence over the temperature range of operation of the device.

In an alternate embodiment one may use, instead of pulsed interrogation light, an AC-modulated interrogating light of a peak intensity which decays in a time shorter than the decay time of the probe luminescence.

5.0 The Measurement of Displacement and Temperature with a Single Probe

The luminescent materials discussed in section 2.0 above can be used as probes for the simultaneous measurement of displacement and temperature with a single probe, or for the simultaneous measurement of temperature and any parameter which controls the position or displacement of a probe. In one preferred arrangement, illustrated in FIG. 5, the probe is a screen 98 which moves along the directions of the arrows and includes two contiguous layers 99 and 100. Layer 99 is comprised of a Cr_{3+}-doped photo-luminescent material, for example Cr:YAG. Layer 100 is light-reflective. Opposite the screen is the distal tip. (tip opposite to the light injection tip) of the optical fiber 91 into which has been injected pulsed interrogating light beam of wavelengths within an optical absorption band of the Cr_{3+}-doped luminescent material of layer 99 and of a pulse duration much shorter than the luminescence decay time τ of this material. The electro-optical system is otherwise the same as that of FIG. 4. The distal tip of fiber 91 illuminates the screen 98 with an interrogating light spot, only part of the intensity of which is incident on the photoluminescent layer 99. As the screen moves, the relative intensities of the interrogating light incident on layers 99 and 100 vary as a function of the position of the screen, and the relative intensities of the light reflected from layer 100 and the time-averaged luminescence light emitted from the Cr_{3+}-doped layer 99 entering fiber 91 will be a function of said position. The luminescence decay time τ of layer 99 will be an accurate indicator of temperature, independent of the position or displacement of the screen.

In a simpler arrangement, one may omit the measurement of the intensity of the light reflected by the screen, as the intensity of the interrogating light incident on the luminescent probe, and hence the time-averaged intensity If of the probe luminescence, will vary with the position or displacement of the probe. The accuracy of the readings obtained with such arrangement may not be as high as those obtained by referencing said luminescence intensity to the intensity of the excitation light reflected by the probe, but should be sufficient for many industrial applications.

Any physical variable which can be converted into a displacement of an object can be sensed and/or measured with this technique. For example, if the screen 99 is attached to the push-rod of a pressure sensing diaphragm, then it could be used for the simultaneous measurement of both temperature and pressure.

In an alternate embodiment of the same invention, the luminescent screen is stationary and the distal tip of the optical fiber is attached to the object undergoing the displacement. The end result is the same: the intensity of the interrogating light spot incident on the luminescent material, and hence the intensity of the luminescence generated therein, varies as a function of the displacement of the object.

Since some changes may be made in the foregoing disclosure without departing from the invention herein disclosed, it is intended that all matter contained in the above description and depicted in the accompanying drawings be construed in an illustrative and not in a limiting sense.

I claim:

1. A fiber optic device for sensing temperature changes in an object or environment, including:

(a) a probe comprised of photoluminescent material characterized by an ability to absorb a fraction αP_o of the intensity P_o of interrogating radiation of suitable pre-selected wavelengths injected into the probe and emit luminescence radiation of wavelengths λ_1 different from the wavelength of the interrogating radiation and an intensity which varies as a known function of α, where α is a fraction smaller than unity and increases with increasing temperature within at least part of the temperature range of operation of the device, said material including luminescence centers chosen from the group of $3d^3$ transition metal ions consisting of divalent vanadium, trivalent chromium and tetravalent manganese ions, the probe being further so characterized that, when excited with transient or periodic optical radiation of wavelengths within an absorption band of said material, it emits luminescence radiation with an intensity which decreases after termination of the excitation radiation with a decay time which decreases substantially with increasing temperature within a range of temperatures;

(b) a source of said transient or periodic optical radiation;

(c) fiber optic means for directing said transient or periodic optical radiation to said probe;

(d) fiber optic means for directing a fraction of the intensity of the luminescence radiation emitted from said probe to photodetector means; and

(e) photodetector and associated electronic means for measuring the decay time of the luminescence emitted from said probe, said decay time being an indicator of the probe temperature.

2. A fiber optic device as claimed in claim 1 wherein the wavelengths of said transient or periodic optical radiation are longer than 600 nanometers and most of the intensity of said luminescence radiation is emitted at wavelengths longer than 700 nanometers.

3. A device as claimed in claim I wherein said luminescence centers are so characterized that, when excited with said transient optical radiation, they emit luminescence radiation with a total quantum efficiency which is substantially invariant or varies only minimally within a temperature range within which the luminescence decay time decreases substantially with increasing temperature.

4. A device as claimed in claim 3 wherein said luminescence radiation is emitted from two distinct excited electronic energy levels of said luminescence centers, one of said levels being higher than the other, the luminescence radiation emitted from said higher level having an intensity which increases with increasing temperature within a temperature range within which the quantum efficiency of the total luminescence is substantially invariant or varies only minimally.

5. A device as claimed in claim 3 wherein the wavelengths of said transient or periodic radiation are said preselected wavelengths at which the probe absorbs said temperature-dependent fraction αP_o of the intensity of said interrogating radiation, the device additionally including means for measuring the intensity of the luminescence radiation generated by the absorption of said fraction αP_o of the intensity of said interrogating radiation, said luminescence intensity being an additional indicator of the probe temperature.

6. A device as claimed in claim 3 and additionally adapted to sense a displacement or position of an object in addition to its temperature and using the same said probe, wherein said displacement varies the intensity of the interrogating light incident on said photoluminescent material in said probe, thereby varying the intensity of said luminescence light emitted by the probe and received by said photodetector means as a function of said displacement.

7. A device as claimed in claim 6 and additionally adapted to measure simultaneously both temperature and a force or pressure, wherein the position or displacement of said object is determined by the force or pressure applied on said object, and the magnitude of the force or pressure is indicated by the position or the magnitude of the displacement of said object.

8. A device as claimed in claim 2 wherein said decay time is within the range from 5×10^{-5} seconds to 2×10^{-3} seconds.

9. A device as claimed in claim 2 wherein the probe is additionally characterized by emitting said luminescence radiation at temperatures at which it also emits temperature radiation, also known as black body radiation, at wavelengths within the spectral range of operation of silicon photodetectors, the intensity of said black body radiation increasing as a known function of temperature.

10. An optical method for measuring the temperature of an object or environment, comprising the steps of:

(a) exposing a probe to the temperature to be measured, said probe including a photoluminescent material characterized by an ability to absorb a fraction αP_o of the intensity P_o of interrogating radiation of suitable pre-selected wavelengths injected into the probe and emit luminescence radiation of wavelengths λ_1 different from the wavelength of the interrogating radiation and an intensity which varies as a known function of α, where α is a fraction smaller than unity and increases with increasing temperature within at least part of the temperature range of operation of the device, said material including luminescence centers chosen from the group of $3d^3$ transition metal ions consisting of divalent vanadium, trivalent chromium and tetravalent manganese ions, the probe being further so characterized that, when excited with transient or periodic optical radiation of wavelengths within an absorption band of said material, it emits luminescence radiation with an intensity which decreases after termination of the excitation radiation with a decay time which decreases substantially with increasing temperature within a range of temperatures;

(b) illuminating said probe with said interrogating radiation generated by a suitable source, thereby generating luminescence radiation emitted by the probe;

(c) directing a fraction of the intensity of said luminescence radiation to photodetector means; and

(d) measuring the decay time of said luminescence radiation, said decay time being an indicator of the probe temperature.

11. A method as claimed in claim 10 wherein said interrogating radiation is directed from said source to the probe via fiber optic means, and said fraction of the intensity of said luminescence radiation is directed to photodetector means via fiber optic means.

12. A method as claimed in claim 10 wherein the wavelengths of said transient or periodic optical radiation are longer than 600 nanometers and at least a fraction of the intensity of said luminescence radiation is emitted at wavelengths longer than 700 nanometers.

13. A method as claimed in claim 10 wherein said luminescence centers are so characterized that, when excited with said transient optical radiation, they emit luminescence radiation with a total quantum efficiency which is substantially invariant or varies only minimally within a temperature range within which the luminescence decay time decreases substantially with increasing temperature.

14. A method as claimed in claim 13 wherein said luminescence radiation is emitted from two distinct excited electronic energy levels of said luminescence centers, one of said levels being higher than the other, the luminescence radiation emitted from said higher level having an intensity which increases with increasing temperature within a temperature range within which the quantum efficiency of the total luminescence is substantially invariant or varies only minimally.

15. A method as claimed in claim 13 wherein the wavelengths of said transient or periodic radiation are said preselected wavelengths at which the probe absorbs said temperature-dependent fraction αP_o of the intensity of said interrogating radiation, the method additionally including the step of measuring the intensity of the luminescence radiation generated by the absorption of said fraction αP_o of the intensity of said interrogating radiation, said luminescence intensity being an additional indicator of the probe temperature.

EXHIBIT E

E

IPITEK
INTEGRATED PHOTONICS TECHNOLOGY
ISO 9001 Registered

EXHIBIT E

26 November 2002

Dr. Marcos Kleinerman
215 Sunset Avenue
Amherst, MA 01002

Dear Dr. Kleinerman:

This is a follow-up to your letter dated October 31, 2002.

IPITEK products are distinguishable from the inventions described in US Patent Numbers 4, 708,494 and 5,090,818. The following analysis clearly shows differences for the claims cited by the inventor. This is not an exhaustive evaluation of the differences but does note some of the differences.

US Patent 4,708,494

Claim 12(a): IPITEK products do not use "luminescence lights from two excited energy levels, the relative intensities of which are known monotonic functions temperature..."

Claim 12 (b): IPITEK products do not use "emission from said two energy levels, the relative intensities of which are a known function of temperature..."

Claim 12 (d): IPITEK products do not require "measuring the relative intensities of said luminescence emissions ..."

Claim 13 is dependent on Claim 12 (a special case thereof) and thus also is distinguishable from IPITEK products.

Claim 19(a) : IPITEK products do not have a : "luminescent decay time that decreases in a known manner with an increase in temperature."

Claim 19(d) IPITEK products do not have " a fiber optic means for directing said luminescence light emitted from said two excited emissive levels of said sensor..."

Claim 19(e) IPITEK products do not have a "means for measuring the decay time of said luminescence..."

US Patent 5,090,818

Claim 1(a) IPITEK products do not have a "probe means ... the relative intensities of the luminescence light emitted from each of said two levels varying as a function of the probe means temperature , the intensity of the luminescence light emitted from said higher level increasing with increasing temperature within a pre-determined temperature range, within which the quantum efficiency of the total luminescence emitted from said two levels is approximately invariant,..."

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Claim 1(a) IPITEK products do not have "the combined luminescence light emitted from said two levels continuing in time beyond the termination of transient excitation light with a decay time of its intensity which decreases in a known manner with an increase in temperature within said temperature range."

Claim 1(e) IPITEK products do not have a "photodetector means for measuring the decay time of the luminescence ..."

Claim 2 is dependent on Claim 1 (a special case thereof) and thus also is distinguishable from IPITEK products.

Claim 7(a) IPITEK products do not "emit luminescence light from two excited electronic energy levels, one of them being higher than the other and having a higher rate of luminescence decay than that of said other level, the relative intensities of the luminescence light emitted from each of said two levels varying as a function of the probe temperature,..."

Claim 7(a) IPITEK products do not have "the combined luminescence light emitted from said two levels continuing in time beyond the termination of transient excitation light with a decay time of its intensity which decreases in a known manner with an increase in temperature within said temperature range."

Claim 7(d) IPITEK products do not "measure the decay time of said luminescence light..."

US Patent 5,332,316

I do not see a need to go over the individual claims of this patent as the arguments cited above also apply to the claims of this US patent. I note that because of the similarity of the claims, the US Patent and Trademark office has required you to disclaim portions of this patent and US Patent 5,090,818 beyond the expiration of US Patent 4,708,494.

You noted a recent article that appeared in *Sensors* magazine, which perhaps misled you. You may be interested to know that the description in that article does not describe the operation of any of the IPITEK products. The marketing advantages of a simplified tutorial explanation of a product in a trade journal often mask the complexities of actual operation.

Sincerely,

James H. Bechtel
Senior Vice President

Cc: William H. Tucker

EXHIBIT F

F

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EXHIBIT G

EXHIBIT G

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Amherst, MA 01002
Tel: (413) 549-7124 Fax: (413) 549-7126 E-mail: marcosk@fiam.net

FAX

To : **Sales Manager, Ipitek**
Fax : (760) 438-1069
From : **Marcos Kleinerman**
Date : January 15, 2003
Subject: Cancellation of my order No. **W253314** to Ipitek's Sales Representative
Pages : 2(including this one)

MESSAGE

Dear Sales Manager,

Last January 2nd I placed an order, No. **W253314**, for an LT500 probe, with your representative Davis Inotek. The order confirmation is attached. Yesterday I was informed by Davis Inotek that you instructed them to cancel my order. Please inform me by letter why you refuse to sell me the probe.

Sincerely,

Marcos Y. Kleinerman